Paleoseismic investigation of the western Garlock fault: Towards an understanding of fault interactions in southern California

Collaborative research with the University of Southern California

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Introduction

This investigation will obtain the first high-quality paleoseismic record for the western Garlock fault in southern California. We will compare our results to recently recovered earthquake records for the central Garlock fault, the San Andreas fault and faults of the eastern California shear zone to test models of stress transference and temporal earthquake clustering. Understanding past fault interaction at local and regional scales is an important step toward one day forecasting future earthquakes, and reducing earthquake losses.

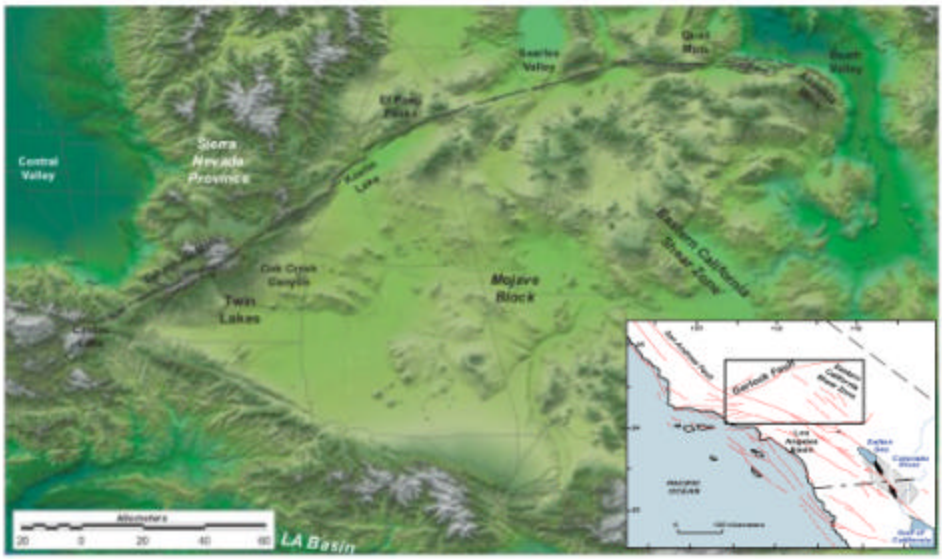

Figure 1. Inset showing active faults in southern California and Mexico in red and the location of the main figure outlined by the black box. Main figure shows the Garlock fault trace represented by the thick black line (Jennings, 1994), major tectonic provinces and key geographic locations along the Garlock fault. Thin black lines mark the major highways and small yellow box near Twin Lakes shows the location of Figure 2.

The only previous paleoseismic investigation of the western Garlock fault interpreted two mid-to late Holocene earthquakes in the Twin Lakes area of the southern Tehachapi Mountains (Stepp et al.,1980) (Figure 1). There, the fault cuts a sag pond that preserves stratified deposits and abundant detrital charcoal, both vital components for identifying and dating prehistoric earthquakes. Unfortunately, the timing of events at the site is poorly constrained because the previous investigation predated modern high-precision AMS 14C and OSL dating techniques. Furthermore, our reinterpretation of trench logs from the Twin Lakes study suggests the possibility for at least two previously unidentified mid-to-late Holocene earthquakes.

To refine and expand the paleoseismic record for the western Garlock fault we initiated a trenching program at the proven Twin Lakes site to (1) corroborate evidence for the two events recorded in by Stepp et al. (1980); (2) determine whether there is evidence for additional events at the site; (3) constrain the timing of events using high-precision dating techniques.

Preliminary Results

To date we have excavated and photo-logged a 38 m-long by up to 4.5 m-deep backhoe trench across the Garlock fault near the western end of the Twin Lakes sag pond (Figure 2). We placed our trench (ECI-1) parallel to and approximately 4 m west of Stepp et al.'s (1980) western trench (S1) to facilitate correlation of events between the two trenches (Figure 2). Trench ECI-1 extended approximately 3 m past the southern shoreline of the sag pond and 4 m further south than trench S1.

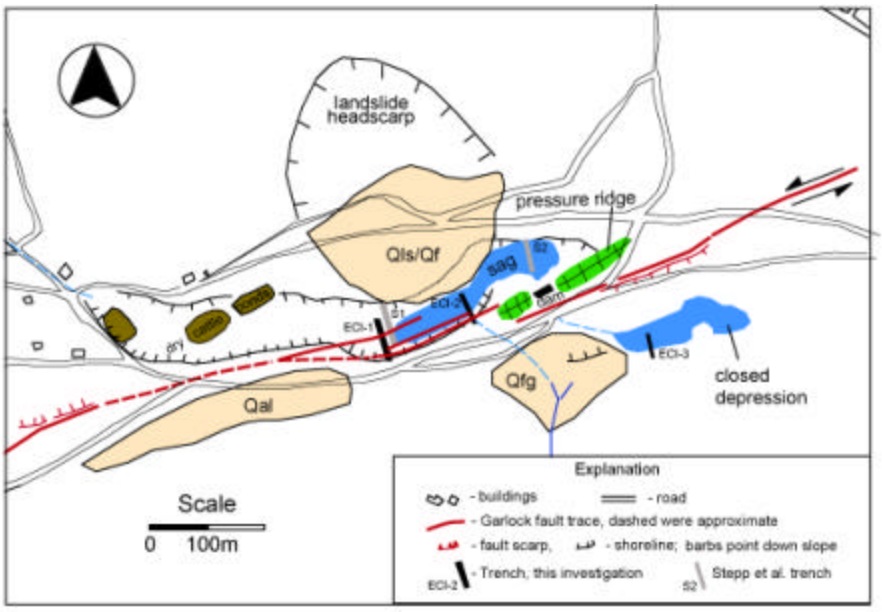

Figure 2. Map of the Twin Lakes site showing fault trace location, depositional environments, and trench sites. Trenches excavated or proposed for tzhis investigation in black. Trenches from Stepp et al. (1980) in grey.

The central portion of trench ECI-1 exposed tabular beds of silt and clayey silt interbedded with thin beds of fine sand, silty sand, and locally, gravel. Near the center of the trench these deposits were cut by a distinctive upward-branching strand of the Garlock fault that died out between 0.25 to 0.5 m of the surface. Separation across this fault ranged from 1.2 m near the base of the exposure to 0.6 m near the surface. Several secondary faults south of the branching strand died out at different stratigraphic levels. Separation across these secondary strands is 0.3 m or less.

Most stratigraphic units and faults in the central portion of trench ECI-1 were correlative to those logged in Stepp et al.'s trench S1. However, near the southern end of our trench, approximately 1 m south of the southern end of trench S1, a previously unidentified 2- to 3 m-wide fault zone juxtaposes Holocene sag pond deposits against crudely bedded older alluvium. This zone is coincident with the abrupt southern margin of the pond and extends to within 1.5 m of the surface, where it is overlain by massive colluvium. Pond deposits on the north side of the fault were tilted upward, with lower units exhibiting more deformation than those near the surface. The width and discordance of units across this southern fault zone suggest it has experienced significantly more movement than other faults exposed in the trenches, suggesting it is the primary strand of the Garlock fault at the Twin Lakes site.

We interpret 3 to 4 events from trench ECI-1, which is consistent with our reinterpretation of logs of Stepp et al.'s (1980) trench S1. Each event is based on at least two and usually three different features indicative of surface rupture, including: upward termination of fault strands; abrupt pinching of units above inferred scarps or colluvial wedges; differential tilting of units and increasing vertical separation of units towards the base of the branching fault zone. Two event horizons from ECI-T1 correlate to events in trench S1. We found additional events after Stepp et al.'s (1980) penultimate event and possibly before their penultimate event.

We've collected over 40 charcoal samples from trench ECI-1 to bracket the timing of the events. Ten samples are currently being processed for AMS 14C dating. However, using crude age constraints from Stepp et al.'s (1980) investigation, we infer the western Garlock ruptured twice in about the last 2200 years and twice prior to 2800 years ago. The latter events may have occurred during a long period of dormancy on the central Garlock fault between about two and five thousand years ago (Figure 3). This challenges assumptions that the Garlock fault ruptures in conjunction with earthquake clusters in the eastern California shear zone.

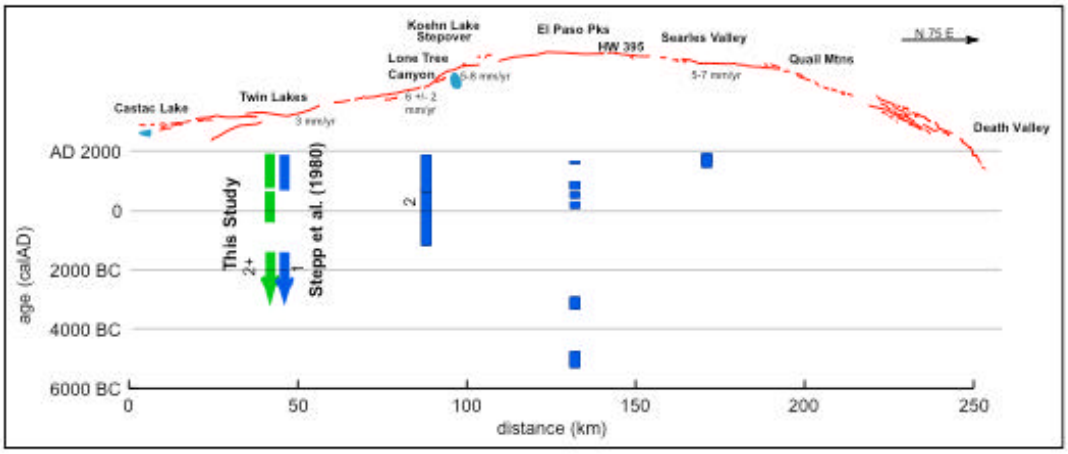

Figure 3. Event chronology versus distance along the Garlock fault. The blue bars show the 2 sigma upper and lowermost calender ages for the bracketing radiocarbon samples. Arrows indicate an open-ended constraint, only an upper bounding age is available in this case (Twin Lakes). Note the strip map at the top of the figure for reference (Jennings, 1994). The only well-dated paleoseismic site on the Garlock occurs at El Paso Peaks (Dawson et al., 2003; McGill and Rockwell, 1998). Previous paleoseismic studies at Twin Lakes found evidence for only 2 earthquakes in the last > 3000 years (Stepp et al., 1980). New trenches at Twin Lakes provide evidence for two additional events at the site (revised record shown in green). Data from Searles Valley from McGill and Sieh (1993) and McGill (1994b). Lone Tree Canyon data from McGill (2003) and Koehn Lake slip rate from Clark et al. (1984). Original data reported in radiocarbon years B.P. was calibrated using Calib 4.3 (Stuiver and Reimer, 1993).

Schedule

In the coming months we plan to:

- Open and log trench ECI-2 approximately 150 m east of trench ECI-1, where the drainage from a small fan crosses the main fault zone (Figure 2). Bedded alluvial deposits would preserve a better event record than the massive colluvial deposits overlying the main fault zone in trench 1.
- Open and log trench ECI-3 across a second sag pond approximately 250 m east and 5 m south of trench ECI-1 (Figure 2). This pond may have been formed by secondary fault strands and may preserve evidence for additional events.
- Finish drafting photo mosaics for trench ECI-1.
- Process additional 14C samples.
- Write final technical report.

Reports Published

None

Non-technical Summary

This project is designed to determine the number and timing of prehistoric earthquakes on the western Garlock fault during approximately the last 4,000 – 5,000 years. By comparing the earthquake record of the western Garlock fault to records from other faults in southern California we will gain a better understanding of fault behavior and interaction.

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